

# Theory of Automata

## Automata

The term "Automata" is derived from the Greek word "αὐτόματη" which means "self-acting".

An automaton with a finite number of states is called a **Finite Automaton (FA)** or **Finite State Machine (FSM)**.

## Introduction to languages

There are two types of languages

- Formal Languages (Syntactic languages)
- Informal Languages (Semantic languages)

## Alphabets

A finite non-empty set of symbols (called letters), is called an alphabet. It is denoted by  $\Sigma$  (Greek letter sigma).

## Note

Empty string or null string Sometimes a string with no symbol at all is used, denoted by (Small Greek Letter Lambda)  $\lambda$  or (Capital Greek letter Lambda)  $\Lambda$ , is called an empty string or null string.

## Strings

Concatenation of finite number of letters from the alphabet is called a string.

Example

If  $\Sigma = \{a,b\}$  then

a, abab, aaabb, ababababababababab

## Words

Words are strings belonging to some language.

Example

If  $\Sigma = \{x\}$  then a language L can be defined as

$L = \{x^n : n=1,2,3,\dots\}$  or  $L = \{x,xx,xxx,\dots\}$

Here  $x,xx,\dots$  are the words of L.

➤ All words are strings, but all strings are not words.

While defining an alphabet of letters consisting of more than one symbols, no letter should be started with the letter of the same alphabet i.e. one letter should not be the prefix of another. However, a letter may be ended in a letter of same alphabet.

$\Sigma_1 = \{B, aB, bab, d\}$

$\Sigma_2 = \{B, Ba, bab, d\}$

$\Sigma_1$  is a valid alphabet while  $\Sigma_2$  is an in-valid alphabet.

## Length of Strings

The length of string s, denoted by  $|s|$ , is the number of letters in the string.

Example

$\Sigma = \{a,b\}$

$s = ababa$

$|s| = 5$

## Reverse of a String

The reverse of a string s denoted by  $\text{Rev}(s)$  or  $s^r$ , is obtained by writing the letters of s in reverse order.

## Defining Languages

The languages can be defined in different ways, such as Descriptive definition, Recursive definition, using Regular Expressions(RE) and using Finite Automaton(FA) etc.

## Descriptive definition of language

The language is defined, describing the conditions imposed on its words.

# Automata Theory Lecture Notes

**Dexter C. Kozen**



## **Automata Theory Lecture Notes:**

*Elements of Automata Theory* Jacques Sakarovitch, 2009-10-01 Automata theory lies at the foundation of computer science and is vital to a theoretical understanding of how computers work and what constitutes formal methods This treatise gives a rigorous account of the topic and illuminates its real meaning by looking at the subject in a variety of ways The first part of the book is organised around notions of rationality and recognisability The second part deals with relations between words realised by finite automata which not only exemplifies the automata theory but also illustrates the variety of its methods and its fields of application Many exercises are included ranging from those that test the reader to those that are technical results to those that extend ideas presented in the text Solutions or answers to many of these are included in the book

Automata and Computability Dexter C. Kozen, 2013-11-11 These are my lecture notes from CS381 481 Automata and Computability Theory a one semester senior level course I have taught at Cornell University for many years I took this course myself in the fall of 1974 as a first year Ph D student at Cornell from Juris Hartmanis and have been in love with the subject ever since The course is required for computer science majors at Cornell It exists in two forms CS481 an honors version and CS381 a somewhat gentler paced version The syllabus is roughly the same but CS481 goes deeper into the subject covers more material and is taught at a more abstract level Students are encouraged to start off in one or the other then switch within the first few weeks if they find the other version more suitable to their level of mathematical skill The purpose of the course is twofold to introduce computer science students to the rich heritage of models and abstractions that have arisen over the years and to develop the capacity to form abstractions of their own and reason in terms of them

**Lectures in Game Theory for Computer Scientists** Krzysztof R. Apt, Erich Grädel, 2011-01-06 Games provide mathematical models for interaction Numerous tasks in computer science can be formulated in game theoretic terms This fresh and intuitive way of thinking through complex issues reveals underlying algorithmic questions and clarifies the relationships between different domains This collection of lectures by specialists in the field provides an excellent introduction to various aspects of game theory relevant for applications in computer science that concern program design synthesis verification testing and design of multi agent or distributed systems Originally devised for a Spring School organised by the GAMES Networking Programme in 2009 these lectures have since been revised and expanded and range from tutorials concerning fundamental notions and methods to more advanced presentations of current research topics This volume is a valuable guide to current research on game based methods in computer science for undergraduate and graduate students It will also interest researchers working in mathematical logic computer science and game theory

*Automata Theory and Formal Languages* H. Brakhage, 1975

**CONCUR 2004 -- Concurrency Theory** Philippa Gardner, Nobuko Yoshida, 2011-03-22 This book constitutes the refereed proceedings of the 15th International Conference on Concurrency Theory CONCUR 2004 held in London UK in August September 2004 The 29 revised full papers presented together with 4

invited papers were carefully reviewed and selected from 134 submissions Among the topics covered are concurrency related aspects of models of computation semantic domains process algebras Petri nets event structures real time systems hybrid systems decidability model checking verification techniques refinement term and graph rewriting distributed programming constraint logic programming object oriented programming typing systems and algorithms case studies tools and environments for programming and verification

CONCUR '98 Concurrency Theory Davide Sangiorgi, Robert de Simone, 1998-08-19 This book constitutes the refereed proceedings of the 9th International Conference on Concurrency Theory CONCUR 98 held in Nice France in September 1998 The 35 revised full papers presented were carefully selected from a total of 104 submissions Also presented are five invited contributions Among the topics covered are moduls of computation and semantic domains process algebras Petri Nets event structures real time systems hybrid systems model checking verification techniques refinement rewriting typing systems and algorithms etc

*Sequences, Groups, and Number Theory* Valérie Berthé, Michel Rigo, 2018-04-09 This collaborative book presents recent trends on the study of sequences including combinatorics on words and symbolic dynamics and new interdisciplinary links to group theory and number theory Other chapters branch out from those areas into subfields of theoretical computer science such as complexity theory and theory of automata The book is built around four general themes number theory and sequences word combinatorics normal numbers and group theory Those topics are rounded out by investigations into automatic and regular sequences tilings and theory of computation discrete dynamical systems ergodic theory numeration systems automaton semigroups and amenable groups This volume is intended for use by graduate students or research mathematicians as well as computer scientists who are working in automata theory and formal language theory With its organization around unified themes it would also be appropriate as a supplemental text for graduate level courses

**Theory And Formal Methods Of Computing 94: Proceedings Of The Second Imperial College Workshop** Chris Hankin, I Mackie, Rajagopal Nagarajan, 1995-10-17 The focus of this workshop was the development of mathematically based techniques of formal specification of system behaviour and the systematic development of implementations The aim is to produce correct efficient implementations in a reliable fashion Topics covered at the workshop include category theory logic domain theory semantics concurrency specification and verification The papers published here range from the purely theoretical to practical applications

*Automata Theory* Harvard University. Division of Engineering and Applied Physics, 1962

**A Course in Formal Languages, Automata and Groups** Ian M. Chiswell, 2009-02-06 This book is based on notes for a master s course given at Queen Mary University of London in the 1998 9 session Such courses in London are quite short and the course consisted essentially of the material in the rst three chapters together with a two hour lecture on connections with group theory Chapter 5 is a considerably expanded version of this For the course the main sources were the books by Hopcroft and Ullman 20 by Cohen 4 and by Epstein et al 7 Some use was also made of a later book by Hopcroft and Ullman 21 The ulterior

motive in the first three chapters is to give a rigorous proof that various notions of recursively enumerable language are equivalent. Three such notions are considered. These are generated by a type 0 grammar recognised by a Turing machine, deterministic or not, and defined by means of a Gödel numbering having defined recursively enumerable for sets of natural numbers. It is hoped that this has been achieved without too many arguments using complicated notation. This is a problem with the entire subject and it is important to understand the idea of the proof which is often quite simple. Two particular places that are heavy going are the proof at the end of Chapter 1 that a language recognised by a Turing machine is type 0 and the proof in Chapter 2 that a Turing machine computable function is partial recursive.

Foundations of Software Science and Computational Structures Helmut Seidl, 2007-03-09. This book constitutes the refereed proceedings of the 10th International Conference on Foundations of Software Science and Computation Structures FOSSACS 2007 held in Braga Portugal in March-April 2007 as part of ETAPS 2007 the European Joint Conferences on Theory and Practice of Software. The 25 revised full papers presented together with the abstract of 1 invited talk were carefully reviewed and selected from 103 submissions. The papers cover a broad spectrum on theories and methods to support analysis, synthesis, transformation and verification of programs and software systems. In particular the following topics are dealt with: algebraic models, automata and language theory, behavioral equivalences, categorical models, computation processes over discrete and continuous data, infinite state systems, computation structures, logics of programs, modal, spatial and temporal logics, models of concurrent reactive distributed and mobile systems, process algebras and calculi, semantics of programming languages, software specification and refinement, type systems and type theory, fundamentals of security, semi-structured data, program correctness and verification.

*Automata and Computability* Dexter C. Kozen, 2014-01-15      Subject Catalog, 1976 Library of Congress, 1976      **SIAM Journal on Computing** Society for Industrial and Applied Mathematics, 2000      **Proceedings of the Twenty-fifth Annual ACM Symposium on Theory of Computing**, 1993      The Australian Computer Journal, 1992      *Fundamentals of Computation Theory* Lothar Budach, 1979      **Computer-aided Verification**, 1994      Subject Catalog Library of Congress, *Fundamentals of Computation Theory*, 1999

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## **Table of Contents Automata Theory Lecture Notes**

1. Understanding the eBook Automata Theory Lecture Notes
  - The Rise of Digital Reading Automata Theory Lecture Notes
  - Advantages of eBooks Over Traditional Books
2. Identifying Automata Theory Lecture Notes
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Automata Theory Lecture Notes
  - User-Friendly Interface

4. Exploring eBook Recommendations from Automata Theory Lecture Notes
  - Personalized Recommendations
  - Automata Theory Lecture Notes User Reviews and Ratings
  - Automata Theory Lecture Notes and Bestseller Lists
5. Accessing Automata Theory Lecture Notes Free and Paid eBooks
  - Automata Theory Lecture Notes Public Domain eBooks
  - Automata Theory Lecture Notes eBook Subscription Services
  - Automata Theory Lecture Notes Budget-Friendly Options
6. Navigating Automata Theory Lecture Notes eBook Formats
  - ePub, PDF, MOBI, and More
  - Automata Theory Lecture Notes Compatibility with Devices
  - Automata Theory Lecture Notes Enhanced eBook Features
7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Automata Theory Lecture Notes
  - Highlighting and Note-Taking Automata Theory Lecture Notes
  - Interactive Elements Automata Theory Lecture Notes
8. Staying Engaged with Automata Theory Lecture Notes
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Automata Theory Lecture Notes
9. Balancing eBooks and Physical Books Automata Theory Lecture Notes
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Automata Theory Lecture Notes
10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
11. Cultivating a Reading Routine Automata Theory Lecture Notes
  - Setting Reading Goals Automata Theory Lecture Notes
  - Carving Out Dedicated Reading Time

12. Sourcing Reliable Information of Automata Theory Lecture Notes
  - Fact-Checking eBook Content of Automata Theory Lecture Notes
  - Distinguishing Credible Sources
13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
14. Embracing eBook Trends
  - Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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